Journal of the Royal Society of Arts

NO. 4961 FRIDAY, 30TH SEPTEMBER, 1955 VOL. CIII

OPENING MEETING OF THE 202ND SESSION

The Opening Meeting of the 202nd Session will take place on Wednesday, 2nd November at 2.30 p.m. The Inaugural Address, entitled *Art in Education*, will be delivered by Dr. Robert W. Holland, O.B.E., M.A., M.Sc., Chairman of the Council.

After the address silver medals awarded for papers read during last session, and other awards, will be presented by the Chairman, and at the conclusion of these formal proceedings tea will be served in the Library. It is hoped that Fellows will be able to take this opportunity to meet the Chairman and Members of the Council.

ARRANGEMENTS FOR THE NEW SESSION

A list of the arrangements for the 202nd Session, as far as they are completed up to the date of publication, will be circulated to Fellows with the *Journal* in about one month's time. The serial publication of announcements of forthcoming meetings will commence in the next issue of the *Journal*, dated 14th October.

NEW EDITION OF LIST OF FELLOWS

A new edition of the list of Fellows, corrected to 30th November, 1954, is now ready, and copies will be sent free of charge to Fellows who apply for them. In addition to the alphabetical section, the list contains a geographical index.

McKNIGHT KAUFFER MEMORIAL EXHIBITION

Some tickets are still available for Fellows of the Society for the private view of the memorial exhibition of work by the late E. McKnight Kauffer and for the opening of the exhibition by Mr. T. S. Eliot, O.M. The private view will be from 10 a.m. to 6 p.m. on Thursday, 6th October, and the opening ceremony

will take place at 3 o'clock on the same afternoon. Applications for these tickets should be made to the Secretary at the Society's House.

The exhibition will be open to the general public from 7th October to 27th November.

INTERNATIONAL EXHIBITION OF MEDALS IN STOCKHOLM

Mr. Munro Runtz, as Chairman of Council at the time of the Society's recent Exhibition of European Medals, 1930–1955, was invited to attend the Sixth Congress of the Fédération Internationale des Éditeurs de Médailles and the Exhibition of Medals accompanying it which has recently been held in Stockholm.

Mr. and Mrs. Runtz arrived in Stockholm on 9th September, and on the following morning were received at the Swedish Museum of National Antiquities where they inspected the F.I.D.E.M. Exhibition of Modern Medals, on the fine quality of which Mr. Runtz commented.

On the evening of the 10th September, Mr. and Mrs. Runtz attended a dinner given in the Swedish Foreign Office, where Mrs. Runtz was accorded the honour of sitting on the left-hand of the host, the Minister of Education. No less than five Directors of Mints were present at this function.

On 11th September they attended a reception at the Town Hall and while in this magnificent building were fortunate enough to see Their Majesties The King and Queen of Sweden, who were attending a Congress there.

EXHIBITION OF EUROPEAN MEDALS, 1930–1955

As announced in the last issue of the *Journal*, the Exhibition of European Medals, 1930–1955 is now on view at the City Museum, Sheffield, where it will remain until 28th October. The exhibition will also visit Norwich, from 8th to 27th November; Lincoln, from 3rd December to 1st January; Leicester, from approximately 5th January to 1st February; Edinburgh, from 15th February to 10th March, and Cardiff where it is expected to open on about 21st March for one month.

As Fellows will remember, the exhibition contains some two hundred medals, and also some coins, from 12 countries. The exhibits were selected with the help of the Royal Numismatic Society and the Fédération Internationale des Éditeurs de Médailles.

INDUSTRIAL ART BURSARIES EXHIBITION

As announced in the last issue of the *Journal*, the winning and commended designs submitted in the 1954 Industrial Art Bursaries Competition will be exhibited at the Gloucester College of Art, Brunswick Road, Gloucester, from 8th to 22nd October and at the City of Canterbury College of Art, St. Peters Street, Canterbury, from 29th October to 12th November.

SOME RECENT DEVELOPMENTS IN THE CHEMISTRY OF NUCLEIC ACIDS

The Pope Memorial Lecture by

SIR ALEXANDER TODD, M.A., D.Sc., F.R.S.,

Professor of Organic Chemistry, University of Cambridge,

delivered to the Society on Wednesday, 18th May, 1955, with

Sir Robert Robinson, O.M., D.Sc., LL.D., F.R.S., Waynflete

Professor of Chemistry, Oxford University, in the Chair

THE CHAIRMAN: We are gathered here to-day to hear the seventh of the memorial lectures to the late Sir William Pope, which were instituted by subscriptions from his friends and admirers to be given under the auspices of the Royal Society of Arts.

Of course, Sir William Pope was a man of many parts. It is very interesting to look at the titles and the authors of the previous lectures, because they illustrate in a remarkable way his characteristic versatility. The very first of them was given by Charles Gibson and was largely on the biographical, personal side. Then Dr. Lampitt, in 1947, spoke of a matter in connexion with which Sir William Pope will always be remembered gratefully, namely, the international relations of scientists, and his work for the International Union of Chemistry. This left its mark and has certainly tended to the cementing of good international relations in science. Dr. Mann spoke of a scientific subject for which Sir William Pope was most widely known and recognized, that is, his researches in stereochemistry. Professor Read spoke of still another side of his work and character, namely, his concern with the question of cultural relations in science. This was allied to Dr. Lampitt's theme, but a different aspect of the subject. Professor Norrish spoke of the work of Lyon Playfair. The history of chemistry was of great interest to Sir William Pope and he was a great admirer of Lyon Playfair. That was certainly a very appropriate subject and, to continue this review of Sir William Pope's manifold activities, Sir Owen Wansbrough-Jones spoke of the help he gave to scientific organization and research in the services. You will remember that it was in Sir William Pope's laboratory that many of the important discoveries of chemical warfare agents were made, and he played a very great part in the organization of chemical defence.

Now to-day we have, to continue this survey, Sir Alexander Todd, Professor of Chemistry in the University of Cambridge, who followed Sir William Pope after a short interval of a few years. Sir Alexander will speak of one of the chief research topics which have been prosecuted in the Cambridge laboratories. That is a very appropriate subject for a memorial lecture, for, although its development is due entirely to the initiative of Sir Alexander Todd, it has nevertheless been facilitated by work carried out in the Chemical School at Cambridge where Sir William Pope was so justly famous.

I need not tell you that Sir Alexander Todd is a man on whom many honours have already been showered. He is the Chairman of the Advisory Committee on Scientific Research which directly advises the Cabinet on so many matters affecting scientific policy and personnel. He has received many academic honours, and I think he will value as much as any of them his selection to deliver a lecture in memory of his distinguished predecessor. If I were to tell you all I know to the advantage of

Sir Alexander Todd, I might perhaps be in danger of provoking the remark which was made by one Welshman to another. The first was enthusiastically praising David Lloyd George, and after a little time the other one said to him: 'Certainly he is a great man, but he is not the Lord God Almighty'. Somewhat taken aback, the first Welshman replied: 'No, but, look you, he is a young man yet'. I think one of the most remarkable things about Sir Alexander Todd is the amount that he has been able to achieve in such a comparatively short period of years.

I will now call on Sir Alexander to deliver his lecture on 'Some Recent Developments in the Chemistry of Nucleic Acids'. This subject is of the very greatest possible importance. It lies at the basis of life in the nucleus of the cell and Sir Alexander Todd will tell us of the latest scientific developments in it.

The following lecture, which was illustrated with lantern slides, was then delivered:

THE LECTURE

It is now 84 years since Miescher published his discovery of *nuclein* in the nuclei of pus cells. In the years that followed, this and similar substances known collectively as nucleic acids were found as characteristic components of all cells, and it was in due course recognized that they rank with carbohydrates and proteins as the three great groups of natural macromolecular substances involved in vital processes. Despite their obvious importance, it is remarkable that until recently the nucleic acids received but little attention from the structural chemist, and our knowledge of them lagged far behind our knowledge of proteins and carbohydrates. Now, however, all this has changed and a remarkable transformation has occurred during the past few years; as a result, the chemistry of the nucleic acids can fairly be said to rest now on a firm foundation and their essential structural features are established. Much remains to be done before we can hope to understand their function and their specificity, but a stage has been reached at which it is possible to go forward with some prospect of a successful outcome.

The known nucleic acids are of two types—the ribonucleic acids which yield the sugar D-ribose upon hydrolysis, and the deoxyribonucleic acids which yield 2-deoxy-D-ribose. Graded hydrolysis of nucleic acids gives first the nucleotides, then the nucleosides, and finally a mixture of purine and pyrimidine derivatives together with one or other of the sugars already mentioned. Schematically the hydrolytic breakdown of the nucleic acids can be represented thus:

Nucleic acids

↓

Nucleotides

↓

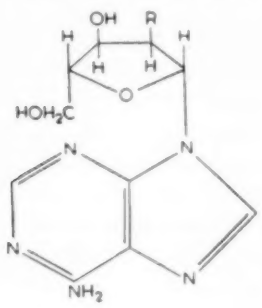
Nucleosides + phosphoric acid

↓

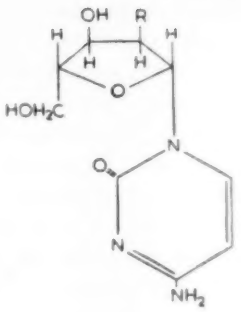
Purines and pyrimidines + D-ribose or 2-deoxy-D-ribose

From ribonucleic acids four nucleosides—adenosine, guanosine, uridine and cytidine—are obtained, and from the deoxyribonucleic acids, six—deoxyadenosine, deoxyguanosine, deoxycytidine, thymidine, 5-methyl-deoxycytidine, and 5-hydroxymethyl-deoxycytidine—of which the two last-named are of limited occurrence. The exceptional occurrence of other nucleosides cannot, of course, be excluded. Ever since it was realized that the nucleotides are phosphate esters of the nucleosides and that the nucleic acids can be regarded as polynucleotides, attempts were made to formulate structures for the latter. The titrimetric work of Levene and Simms[1] led to a general concept of nucleic acid structure, in which the individual nucleoside residues were joined together by phosphodiester linkages and eliminated from consideration either ether or pyrophosphate linkages. This simple formulation has become generally accepted and, although other types of linkage have been suggested from time to time, such suggestions lack corroborative chemical evidence. Of these suggestions, the phosphotriester linkage, which might represent a branching point in a polynucleotide chain, has been most widely canvassed. As will be mentioned later, recent evidence suggests that its occurrence is most unlikely. Essentially, the nucleic acids are to be regarded as polydiesters of phosphoric acid. It is the purpose of this lecture to outline briefly the present state of our knowledge of their detailed structure, and to put before you some of the recent findings which bear upon it.

It is clear that an understanding of the details of nucleic acid structure must rest on a knowledge of the precise structure of the individual nucleosides and nucleotides and of the position as well as the nature of the internucleotidic linkage. The study of these problems has been pursued by my colleagues and myself in Cambridge during the past ten years or so, using the methods of organic chemistry, and I believe that a consideration of the development of these studies and of related biochemical work affords the simplest exposition of nucleic acid structure as we know it to-day. Our studies were simplified, at least in their earlier phases, by the pioneer work of earlier investigators, and particularly of Levene, who established the general features of nucleoside structure in a series of outstanding investigations about twenty years ago, and of Gulland, who first provided evidence for the probable location of the sugar residues in nucleosides. In the initial phase of our work we were able to extend this earlier work, and to establish in every detail the structure and stereochemical configuration of the natural ribonucleosides and to confirm our findings by total synthesis. They are in every case β-D-ribofuranosides, the sugar being attached at N_9 in the purine nucleosides and at N_3 in the pyrimidine nucleosides[2]; typical examples are adenosine (I; R = OH) and cytidine (II; R = OH). The total synthesis of the natural deoxyribonucleosides is still outstanding but their structure as β-2-deoxy-D-ribofuranosides with the sugar at N_9 in the purine and N_3 in the pyrimidine nucleosides has been rigidly established in the cases of deoxyadenosine (I; R = H) deoxycytidine (II; R = H) and thymidine[3]; the β-configuration of deoxy-guanosine has been inferred, though not rigidly proven.

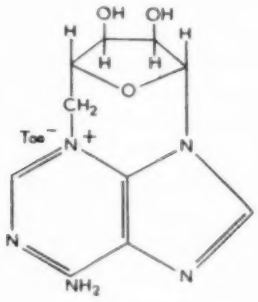


I

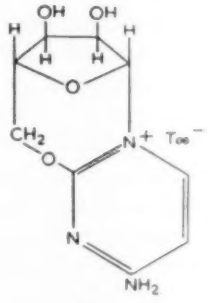


II

Space does not permit a detailed description of the very extensive researches involved in this phase of the work but mention may be made of an interesting group of nucleoside derivatives, which were discovered during its course and which were used to determine the stereochemical configuration at the glycosidic linkage. These are the *cyclo*nucleosides which were first discovered during work on the 5′-*p*-toluenesulphonyl derivatives of adenosine and cytidine[1]; on heating, these *p*-toluenesulphonyl derivatives pass readily by intramolecular alkylation, into N^3: 5′-cycloadenosine (III) and O^2: 5′-*cyclo*cytidine (IV) salts whose formation is only possible if the original nucleosides are β-glycosides.



III



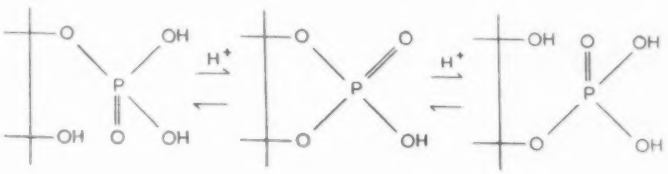
IV

More recent work has shown that *cyclo*nucleoside derivatives are readily obtained from all the pyrimidine nucleosides and that not only O^2: 5′- but also O^2: 2′- and O^2: 3′-cyclonucleosides can be obtained, inversion of configuration of the sugar hydroxyl occurring in the two latter cases. The ease with which *cyclo*nucleosides are formed is most striking and prompts the question whether they may not have some role in biological processes; no experimental evidence bearing on this question has, however, been reported to date.

Following the clarification of nucleoside structure, the next phase of our studies on nucleic acid structure was clearly the synthesis of the various mononucleotides derivable from the nucleosides by introducing a phosphate group

into the carbohydrate portion of the molecule. With this end in view a comprehensive study of possible phosphorylation procedures was made, and a number of new and flexible methods were devised. Of these, perhaps the most successful employed dibenzyl phosphorochloridate $(C_6H_5CH_2O)_2$ POCl[6] as phosphorylating agent. Using these new methods with appropriately protected intermediates, unambiguous syntheses were effected for all the ribonucleoside-5′ phosphates[7] and for the 3′- and 5′- phosphates of the four main deoxyribonucleosides[8]. Unambiguous synthesis of the 2′- and 3′- phosphates of the ribonucleosides proved a difficult undertaking, partly because of the difficulty of obtaining ribonucleosides blocked simultaneously in the 3′- and 5′- positions, and partly because of phosphoryl migration which is discussed below. In their early studies Brown and Todd[9] were able to prepare, for example, adenosine-2′ and -3′ phosphates by phosphorylating 5′-trityladenosine, but they were unable at the time to say which was the 2′- and which the 3′- derivative; the same was, of course, true of other ribonucleoside 2′- and 3′- phosphates prepared in similar fashion from the appropriate 5′- trityl derivatives.

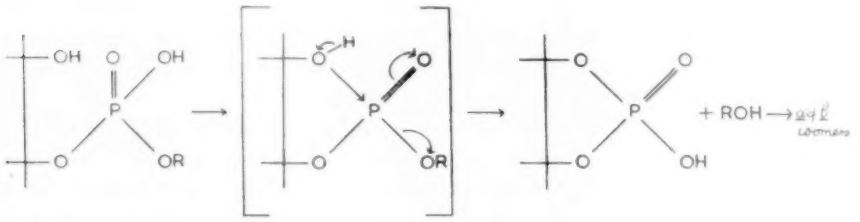
Until 1949 it had been believed that alkaline hydrolysis of ribonucleic acids yielded only four nucleotides which were believed, on evidence now known to be of doubtful validity, to be the 3′- phosphates of the four ribonucleosides. In that year, however, application of ion-exchange chromatography to alkaline hydrolysates of ribonucleic acid by Carter and Cohn[10] showed that they contained not four, but eight nucleotides made up of four pairs of isomers—an *a* and a *b* nucleotide corresponding to each of the four ribonucleosides. Since it is now known, on the basis of many kinds of evidence, that the four *a* nucleotides all have the phosphate residue in the same position and the *b* nucleotides likewise it will simplify matters if, for the moment, we discuss the problem as it concerned one specific case—that of the adenylic acids *a* and *b*—bearing in mind that what is said here about this pair of isomers applies equally to each of the other pairs. Adenylic acids *a* and *b* were shown to be identical with the synthetic 2′- and 3′- phosphates of adenosine although, as already indicated, it was not at that time known which was the 2′- and which was the 3′- isomer. Brown and Todd[9] observed that, although quite stable in alkaline solution, acid solutions of either isomer undergo phosphoryl migration giving an equilibrium mixture of both. This interconversion can be written formally as follows:



Even more interesting was the behaviour of simple monoesters of the *a* and *b* nucleotides. Diesters of phosphoric acid are normally very resistant toward

alkaline hydrolysis. Monoesters of the *a* and *b* nucleotides are, however, labile to alkali, undergoing ready hydrolysis with loss of the ester group and formation in every case, of a mixture of *a* and *b* nucleotides[9]. This remarkable ease of hydrolysis is also shown by esters of the glycerophosphoric acids, and it is clear that the structural feature causing alkali-lability in all these cases is the presence of a *cis*-hydroxyl group on a carbon atom adjacent to that bearing the phosphate residue.

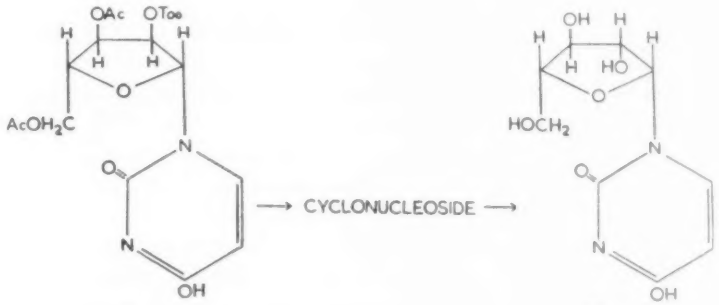
The postulated mechanism of hydrolysis given below has received confirmation from kinetic studies using isotopes[11]. The formation of the cyclic phosphate as an intermediate has been demonstrated and the nucleoside-2′ : 3′ cyclic phosphates have been synthesized and shown to have the expected properties[12].



It should be noted that the expulsion of the esterifying group R is an inevitable consequence of the cyclization step—one of the esterifying groups clearly must be expelled if the phosphorus atom is to retain its normal valency, and mere rupture of either of the linkages to the nucleoside residue would give no degradation of the molecule; a neutral cyclic triester of phosphoric acid is not an intermediate in the process (although in formal schematic representations of the hydrolytic process in complex molecules it may at times be convenient to write the intermediate as if it were). The production of a mixture of *a* and *b* nucleotides on further hydrolysis of the cyclic phosphate is to be expected in view of the near equivalence of the two ester linkages in it.

The structural theory of the nucleic acids was, in fact, developed during the period when the terms *a* and *b* were used for the isomeric nucleotides, but since a resolution of the 2′- and 3′- phosphate problem has since been achieved it will be convenient to report it at this stage. Brown, Fasman, Magrath and Todd[13] were able to prepare a homogeneous x : 5′- diacetyladenosine and to phosphorylate it. Subsequent removal of the protecting groups yielded *exclusively* adenylic acid *a*. This showed clearly that no phosphoryl migration had occurred during any of the operations, and hence that the x : 5′-diacetyl adenosine was the *b* : 5′diacetyl derivative. The diacetyl compound was then tosylated and the position of the stable tosyl group was established by degradative methods as $C_{3'}$. It followed rigidly that the diacetyladenosine used was 3′ : 5′-diacetyladenosine and hence that adenylic acid *a* is adenosine-2′ phosphate. It was also shown by X-ray crystallographic analysis that adenylic acid *b* is adenosine -3′ phosphate. The same conclusion was reached by Khym and Cohn[14] by an ingenious

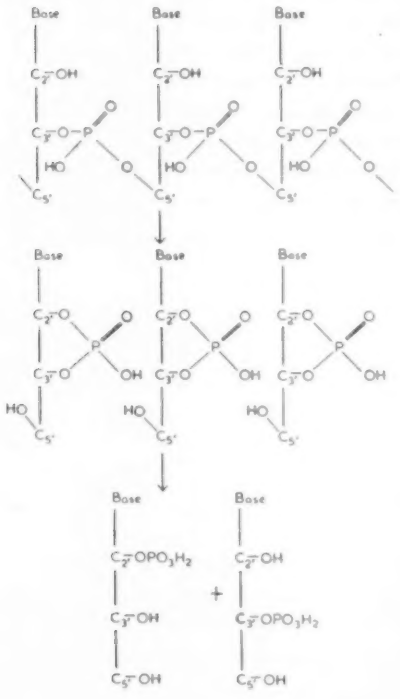
application of differential hydrolysis of the nucleotides on ion-exchange resins. In addition to physical evidence, chemical proof that uridylic acid *a* is uridine-2′ phosphate and hence that cytidylic acid *a* is cytidine-2′ phosphate has been provided by recent work in Cambridge by Dr. Varadarajan[15]. It follows the same general pattern as the work on adenylic acid *a*, but the location of the tosyl group in the *a*-tosyl-*b* : 5′-diacetyluridine was determined by a neat application of the *cyclo*nucleosides. The tosyldiacetyl derivative was readily converted to a *cyclo*nucleoside which was then reconverted to a diacetylnucleoside by opening the *cyclo*-structure at O^2. The nucleoside so obtained was the β-D-arabofuranoside of uracil (VI) showing conclusively that the tosyl group in the original compound was at C_2', that is that it was 2′-tosyl-3′ : 5′-diacetyluridine (V).

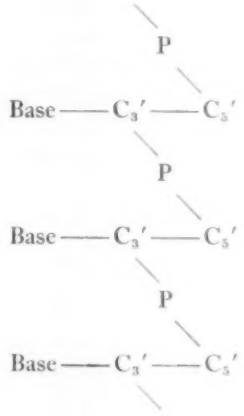


V VI

It has long been known that ribonucleic acids hydrolyse readily with alkali giving simple nucleotides; no larger fragments have ever been obtained. Deoxyribonucleic acids, on the other hand, are not readily degraded by alkali and do not by this means yield simple nucleotides. Based on their observations on the alkali-lability of the esters of the *a* (2′) and *b* (3′) nucleotides, Brown and Todd[16] advanced a simple explanation of the hydrolytic behaviour of the nucleic acids and thence to develop a general theory of their structure. The scheme below (in which Base —— $C_{2'}$ —— $C_{3'}$ —— $C_{5'}$ is used as an abbreviated expression for a nucleoside residue) represents in a formal way the alkaline breakdown of a ribonucleic acid; it is based on the strict analogy which exists between the monoester of a nucleotide and a polynucleotide. The scheme predicts what is, in fact, observed, namely complete hydrolysis to a mixture of the 2′- and 3′- phosphates of the respective nucleosides. It may be noted, too, that the intermediate cyclic phosphates have more recently been isolated by very mild alkaline treatment, further supporting the general thesis. The reason for the comparative stability of the deoxyribonucleic acids is apparent; having no hydroxyl on $C_{2'}$, they cannot undergo a cyclization process (transesterification) and so show the normal stability of diesters of phosphoric acid. The 3′ : 5′- internucleotidic linkage shown in the scheme was postulated for all nucleic acids by Brown and Todd[16], although its complete justification depends on other evidence to be mentioned later.

Deoxyribonucleic acids: These acids are formulated as linear polynucleotides with a recurring 3′ : 5′ phosphodiester linkage[16].



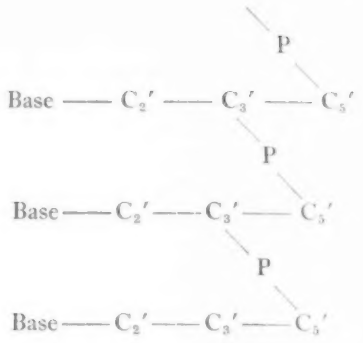


This formulation is in agreement with their stability towards alkali and with the fact that the deoxyribonucleotides formed by enzymic hydrolysis have been shown to be nucleoside-5′ phosphates by enzymic methods[17] and by synthesis[8]. The production of pyrimidine nucleoside 3′ : 5′-diphosphates on acid hydrolysis[18], also accords with this structure, showing as it does the participation of both $C_{3'}$ and $C_{5'}$ in the internucleotidic linkage. Furthermore, the recent synthesis by Michelson and Todd[19] of a dithymidine dinucleotide containing the 3′ : 5′-internucleotidic linkage and the demonstration that its behaviour towards enzymes is precisely that of the dinucleotidic fragments obtained in solution from enzymic digests of deoxyribonucleic acids, is a further support for the above formulation.

The alkali-stability of the isolated deoxyribonucleic acids would seem to preclude the presence in them of branched chain structures since the only type of branching which could occur would be on phosphorus by way of alkali-labile triester groupings. X-ray evidence, too, favours a linear unbranched structure.

As yet no method is available for determining the sequence of residues in deoxyribonucleic acids.

Ribonucleic acids: Brown and Todd[16] postulated a recurring 3′ : 5′-linked polynucleotide structure for the main chain in ribonucleic acids

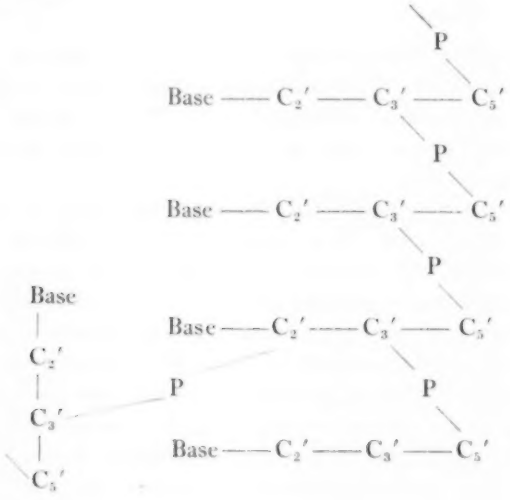


The results of alkaline hydrolysis already mentioned show that C_2' or C_3' is one point of attachment of the internucleotidic linkage. Since treatment of ribonucleic acids with snake venom diesterase[20] or with ribonuclease followed by intestinal phosphatase[21] gives large amounts of nucleoside-5′ phosphates it is clear that C_5' is also involved.

A variety of products can be obtained by the action of crystalline pancreatic ribonuclease on ribonucleic acids. Short action gives, in addition to larger oligonucleotides, the cyclic 2′ : 3′- phosphates of cytidine and uridine. Further action yields the 3′- phosphates of cytidine and uridine together with a variety of small polynucleotides in which the terminal residue bearing a phosphate group at C_3' is always a pyrimidine nucleoside residue[22]. The inferred specificity of the enzyme for linkages attached to pyrimidine residues has been confirmed and defined by studying its action on synthetic nucleotide esters[23] and nucleoside-2′ : 3′ cyclic phosphates[24]. Ribonuclease attacks the cyclic 2′ : 3′-phosphates of uridine and cytidine yielding exclusively the corresponding 3′-phosphates; it is without action on the cyclic phosphates of adenosine and guanosine. Again, it has no action on simple esters of purine nucleotides whether the phosphate group be in the 2′, 3′, or 5′ position nor on esters of pyrimidine nucleotides bearing phosphate at C_2' or C_5', but it hydrolyses esters of pyrimidine nucleoside-3′ phosphates smoothly to the nucleoside-3′ phosphates, the cyclic 2′ : 3- phosphates being intermediates. It follows from these observations that the pyrimidine nucleoside residues in ribonucleic acids must have the internucleotidic linkage at C_3' and that ribonuclease acts in the same way as alkali except in so far as it produces only the C_3'- nucleotides instead of a mixture of the C_2' and C_3' isomers. Similar studies of the action of spleen nuclease (which attacks both purine and pyrimidine sites in ribonucleic acids) on simple nucleotide esters show that purine nucleoside residues in the chain are also linked at C_3'[25]. It seems therefore that the postulated 3′ : 5′- internucleotidic linkage may be taken as established, and all other evidence appears to confirm it. There is no real evidence for any other type of internucleotidic linkage.

The possibility that branched-chain structures may occur in ribonucleic acids has been frequently discussed. Bearing in mind the essential requirement

of alkali-lability and the mechanism of alkaline hydrolysis, two types of branching can be considered. The first involves branching on phosphorus by way of triester linkages, and this has been frequently canvassed in the past. Recent studies in our laboratory have shown that diesters of ribonucleoside-3′ phosphates (which are analogous in structure to triester branch points) are extremely unstable even in approximately neutral pH ranges; it seems, therefore, very unlikely that ribonucleic acids can exhibit branching of this type since the postulated structures could hardly survive the normal isolation procedures. The other possible type of branching is not so easily disposed of; in it C_2' in one residue of the main chain, is joined by a phosphodiester linkage to C_3' in the first residue of the branching chain[16].



In this type of branching, the first residue in the branch cannot be linked to the main chain through C_5', for in such a structure neither residue would contain a free hydroxyl adjacent to the phosphate linkage which would permit the cyclization step required in alkaline or ribonuclease hydrolysis; as a result alkaline hydrolysis of the polynucleotide would give fragments larger than simple nucleotides. No decisive evidence has yet been presented which allows us to decide whether ribonucleic acids are branched or unbranched. All that can be said is that if branching occurs it must be of the type discussed here. Further experimental evidence from synthesis or from physical measurements is necessary before the branching problem can be settled.

Apart from branching, the difference between individual ribonucleic acids presumably lies in the sequence of nucleoside residues in the polynucleotide chain. A method suitable for sequence determination in ribonucleic acids has been proposed[26]. It depends on the oxidation of a terminal nucleoside residue containing a free 2′ : 3′-α-glycol system with periodate followed by expulsion of the oxidized residue under very weakly alkaline conditions by means of an

elimination reaction leaving the rest of the molecule intact. The validity of this stepwise degradation procedure has been confirmed in a number of oligonucleotides[27], but it cannot be applied to the nucleic acids themselves until a homogeneous nucleic acid is available for study; unfortunately nucleic acids as ordinarily obtained are not heterogeneous mixtures.

It may be observed that according to whether a nucleic acid bears its terminal phosphoric acid group at C_3' or C_5' in a nucleoside residue, it may be regarded as a polyester in which the monomeric units are nucleoside-3′ or nucleoside-5′ phosphates. To which of these types the natural nucleic acids belong is at present unknown. True, examples have been reported conforming to both, but since any partial degradation of a polynucleotide of the second type would give products with terminal 3′-phosphate groups, the significance of these reports is still uncertain and their assessment may have to await closer knowledge of the mechanism by which polynucleotides are synthesized in the living organism.

Since the postulation of general structures for the nucleic acids and the availability of precise knowledge about the individual nucleotides, much attention has been devoted to their macromolecular configuration or conformation. The conformation of the large nucleic acid molecules is obviously important in connection with their biological function and a good deal of information is now available regarding the deoxyribonucleic acids whose sodium salts can be obtained in crystalline form as fibres and can be studied by X-ray methods. The position is less satisfactory with regard to the ribonucleic acids which are very difficult to get in fibre form and give generally unsatisfactory X-ray diagrams.

Following earlier suggestions by Pauling and others, Watson and Crick[28] advanced a structure of the macromolecule of deoxyribonucleic acids which appears to be sufficiently in harmony with chemical and X-ray data to be widely accepted, at any rate, in all essential features. According to this view the deoxyribonucleic acid molecule is pictured as a double helix in which two helical chains are coiled round the same axis. Both chains follow right-handed helices but the sequence of residues in the two chains run in opposite directions. The pyrimidine and purine bases are on the inside of the helix and the phosphate groups on the outside. The nucleotides occur at intervals of 3·4A in the direction of the long axis and the helix repeats itself every ten nucleotides (that is, 34A). In this structural picture the two helical chains are held together by the purine and pyrimidine bases which lie in a plane perpendicular to the long axis of the molecule and are joined together by hydrogen bonds. Assuming the most likely tautomeric forms of the bases, the formation of these hydrogen bonds can be seen on models to be highly specific and only certain pairs of bases can be at once bonded and fitted into the helical structure. The only pairings which seem reasonable are adenine-thymine and guanine-cytosine, so that the sequence of nucleoside residues in one chain in the double helix will, in fact, determine the sequence in the other. This specific pairing of bases is strongly supported by the analytical finding that in the deoxyribonucleric acids the molar ratios adenine/thymine and guanine/cytosine are close to unity, whereas the ratio between, say, adenine and guanine varies considerably in different acids. We need not

here elaborate the arguments and evidence in detail, but in sum, the Watson-Crick formulation is strongly favoured and is in agreement with the physical and chemical facts.

This picture of the deoxyribonucleic acid molecule has many attractive features, and physicists, as well as chemists and biologists, have not been slow to speculate about its possible implications. One of the most obvious is the way in which it can give a picture of the replication of a specifically constituted deoxyribonucleic acid, and hence of the transmission of the hereditary characteristics thought by many workers to be one of the main functions of deoxyribonucleic acids in the cell nucleus. For, if we imagine first of all the separation of the two strands of the double helix and, further, imagine new deoxyribonucleic acid chains being built up alongside these separated strands, it is clear that the specific hydrogen-bonding mentioned above will lead to the duplication of the original double helix in each case. The deoxyribonucleic acid chain in a cell would thus be a kind of permanent template which would be handed on in the reproductive process. Much argument has, of course, developed on the mechanics of such a process of unwinding as I have imagined above, but there can be no doubt that we have here a most attractive idea, and one which may well lead to important developments in biology.

REFERENCES

1. P. A. Levene and H. S. Simms, *J. Biol. Chem.* 1925, **65**, 519 ; 1927, **70**, 327.
2. For review *cf* Kenner, *Fortschr. Chem. org. Naturstoffe* 1951, **8**, 96.
3. D. M. Brown and B. Lythgoe, *J. Chem. Soc.* 1950, 1990 ; W. Andersen, D. H. Hayes, A. M. Michelson and A. R. Todd, *ibid* 1954, 1882 ; A. M. Michelson and A. R. Todd, *ibid.* 1955, 816.
4. V. M. Clark, A. R. Todd and J. Zussman, *J. Chem. Soc.* 1951, 2952.
5. A. M. Michelson and A. R. Todd, *J. Chem. Soc.* 1955, 816.
6. F. R. Atherton, H. T. Openshaw and A. R. Todd, *J. Chem. Soc.* 1945, 382.
7. J. Baddiley and A. R. Todd, *J. Chem. Soc.* 1947, 648 ; A. M. Michelson and A. R. Todd, *ibid.* 1949, 2476.
8. A. M. Michelson and A. R. Todd, *J. Chem. Soc.* 1953, 951 ; 1954, 34 ; D. H. Hayes, A. M. Michelson and A. R. Todd, *ibid.* 1955, 808.
9. D. M. Brown and A. R. Todd, *J. Chem. Soc.* 1952, 44.
10. C. E. Carter and W. E. Cohn, *Federation Proc.* 1949, **8**, 190.
11. D. Lipkin, P. T. Talbert and M. Cohn, *J. Amer. Chem. Soc.* 1954, **76**, 2871.
12. D. M. Brown, D. I. Magráth and A. R. Todd, *J. Chem. Soc.* 1952, 2708.
13. D. M. Brown, G. D. Fasman, D. I. Magrath and A. R. Todd, *J. Chem. Soc.* 1954, 1448. *Nature*, 1953, 172, 1184.
14. J. X. Khym and W. E. Cohn, *J. Amer. Chem. Soc.* 1954, **76**, 1818.
15. Unpublished results.
16. D. M. Brown and A. R. Todd, *J. Chem. Soc.* 1952, 52.
17. C. E. Carter, *J. Amer. Chem. Soc.* 1951, **73**, 1537.
18. C. A. Dekker, A. M. Michelson and A. R. Todd, *J. Chem. Soc.* 1953, 947.
19. A. M. Michelson and A. R. Todd, *J. Chem. Soc.* 1955, in press.
20. W. E. Cohn and E. Volkin, *Arch. Biochem. Biophys.* 1952, **35**, 465.
21. W. E. Cohn and E. Volkin, *Nature*, 1951, **167**, 483.
22. R. Markham and J. D. Smith, *Biochem J.* 1952, **52**, 558.
23. D. M. Brown and A. R. Todd, *J. Chem. Soc.* 1953, 2040.
24. D. M. Brown, C. A. Dekker and A. R. Todd, *J. Chem. Soc.* 1952, 2715.
25. D. M. Brown, L. A. Heppel and R. J. Hilmoe, *J. Chem. Soc.* 1954, 40.
26. D. M. Brown, M. Fried and A. R. Todd, *Chem. Ind.* 1953, 352.
27. P. R. Whitfield and R. Markham, *Nature*, 1953, **171**, 346.
28. J. D. Watson and F. H. C. Crick, *Nature*, 1953, **171**, 737.

DISCUSSION

THE CHAIRMAN: Sir Alexander Todd has thanked us for the patience with which we have listened to him. I think if instead of that he said impatience he might be more correct, because he has so whetted our appetites that we are anxious to know much more about the subject and to listen to him further. I am sorry that this lecture could not have been twice as long as it was. In introducing Sir Alexander Todd, I did not dwell on his manifold scientific accomplishments. They range from early work with Borsche and other collaborators who did very distinguished work on

vitamin-B^2, and now to work on insect pigments and some of the mould metabolites and many other problems. In addition to the outstanding developments of which we have heard this afternoon, he is elucidating the chemistry of B^{12}. I think that we must recognize that all this work which he and his school of collaborators have been able to carry out on the nucleic acids is of quite fundamental importance. I was very impressed with the way in which he stated in a short sentence that the structures of many of these compounds were confirmed by synthesis. There is a great deal of labour implied in that one remark, and if the fascinating vistas which he has opened up to us this afternoon have made it possible for us to take a glimpse into these mysteries, it is only because of the fundamental preparatory studies which Sir Alexander Todd has undertaken, because of his success in laying the foundations, and then perhaps the larger bricks and sections of the actual structures which are found in the nucleic acids.

I think your applause has shown how much you have appreciated the lecture this afternoon and I will now call on Sir John Simonsen to propose a vote of thanks to the lecturer.

SIR JOHN SIMONSEN, F.R.S.: We are fortunate to-day in having on the platform two of the most distinguished British chemists, and I stress the word 'British' because Sir Alexander Todd comes from across the border. In the chair this afternoon we have the Past President of the Royal Society and, which is of particular interest to this Society, we have one of our Albert Medallists. I think Sir William Pope, if he could have been here to-day, would have been very gratified to listen to this memorial lecture. It would have appealed to him that the School of Chemistry at Cambridge was such a hive of activity. In his later years he took a great interest in the biological applications of chemistry and for this reason also this lecture would have appealed to him. In Sir Alexander's lecture to-day we see, as in all his work, that he only attempts problems of real difficulty and of fundamental importance. I think there could be few subjects in organic chemistry and biochemistry of greater importance than that of the nucleic acids. He has fascinated us, not only by the originality of thought, by the skill in experimental work, but also by the remarkable manner in which he has presented the facts to us, so that those who are not masters in this field could at any rate quite readily understand the progress which he has made. I should therefore like to propose a vote of thanks both to our chairman, Sir Robert Robinson, and our lecturer, Sir Alexander Todd.

MR. E. MUNRO RUNTZ (Chairman of Council of the Society): I second Sir John Simonsen's vote of thanks with very great pleasure.

The vote of thanks having been carried with acclamation the meeting then ended.

THE MEDAL IN ART AND SOCIETY

A paper by

JEAN BABELON,

Conservateur en Chef du Cabinet des Médailles Bibliothèque Nationale, Paris, read to the Society on Tuesday, 28th June, 1955, with Professor Michael Grant, O.B.E., Litt.D., President of the Royal Numismatic Society, in the Chair

THE CHAIRMAN: May I begin by saying how delighted the Royal Numismatic Society, of which I am President, has been to collaborate with the Royal Society of Arts in the preparation of this current Exhibition of European Medals, 1930–1955; and may I offer my warmest congratulations to Mr. Luckhurst and to Mr. Cleveland-Stevens, the organizer, for this successful and unusual, indeed unprecedented, event. I believe this display will convince those who have seen it—and I am glad to hear how many they are—of the living vitality of the medal.

To round off and sum up the exhibition, and to place it in its proper perspective, we are very fortunate to have with us Monsieur Jean Babelon, Conservateur-en-chef of the Cabinet des Médailles at the Bibliothèque Nationale. No living person has done more to tell us about the place of medals in the history of our civilizations. One has only to recall his histories of medallic art and of French medals, his history of Paris from medals, and his work on Pisanello, besides much else. Moreover, there is nobody better equipped than he to tell us how the art of the medal, although independent, is related to other arts and to the artistic developments of successive epochs. Visitors to the exhibition will no doubt have seen that his head very suitably appears on two of the medals exhibited there. When one thinks of the important works he has written between the execution of these two portraits one is tempted to look at them in the spirit of that well-known advertisement 'before' and 'after'; and it is gratifying to see, as one is supposed to see from the advertisement, that if anything the change in his appearance has been for the better and not for the worse during the passage of those years of important production. Finally, before retiring in favour of Monsieur Babelon may I state my personal interest? That is, that like many of those in this gathering to-day I have frequently visited the Cabinet des Médailles, and I have always received a most hospitable welcome. It is always a very great delight to go and see their remarkable wealth, and another great pleasure is the courteous reception that one receives. It is therefore very particularly agreeable for me to have the opportunity to-day of welcoming here on your behalf Monsieur Babelon to talk on 'The Medal in Art and Society'.

The following paper, which was illustrated with lantern slides, was then read:

THE PAPER

It has been said that the medal is the proper expression of the Renaissance and, as is the case for the things that have been frequently repeated, there is certainly a high degree of accuracy in such an assertion. At least, we shall not be guilty of exaggerating the importance of our subject, considering that the medal, far from being a minor art, is the medium invented by a society to give

Left: *Augustale of the Emperor Frederick II, 1198–1250.* 20 mm.

Aurei of the Empresses Crispina, c. 177, Faustina, c. 160, and Didia Clara, 193. 19 mm.

Right: *Pisanello, attributed to Marescotti, c. 1440.* 57 mm.

Right: *Isotta da Rimini, by Matteo de Pasti. 1466.* 84 mm.

Left: *Leo Battista Alberti, self portrait, c. 1450.* 198 — 135 mm.

Right: *Reverse of medal of Isotta da Rimini* (above)

Left: *Lodovica Tornabuoni, Florentine school, c. 1486.* 80 mm.

Right: *Giovanna Albizzi, wife of Lorenzo Tornabuoni, Florentine school, c. 1486.* 77 mm.

Left: *Lorenzo de Medici, Florentine school, c. 1490.* 92 mm.

Left: *Gizolamo Savonarola, Florentine school, late XVth century.* 90 mm.

Right: *Medallion of Queen Elizabeth I of England, by Hilliard, 1588.* 58 × 50 mm.

Left: *Wax Medallion of Louis XIV of France, by Roussel, c. 1687.* 111 mm.

utterance to its moods and manners. As a matter of fact, that is precisely what occurred in Italy during the last part of the fifteenth century. But as every historical fact has its forerunners, and we do not believe in abiogenesis, it seems allowable to seek in the past for the origin of what we call, at the present time, a *medal*; that is, a round piece of metal bearing on each face a figure in relief as a coin, but not destined to promote economic transactions, and made exclusively, as was explained by Benvenuto Cellini, for the sake of ostentation.

To the student of antiquity, many works of art suggest themselves as the ancestors of the medal. In Greek and Roman times, a coin, as well as being an instrument of trade, corresponded to the everlasting desire for propaganda, in which we indulge nowadays in many other ways. Propaganda is the exaltation of an idea or an individual, with the object of attaining a determined advantage. Let us call it publicity, in its modern form. It has different aspects according to whether it is merely political, or more exclusively personal. The coin was the outward sign of the dignity of the state. A city might manifest its independence or autonomy by the types of its coins, the representation of its gods, or the easily identified symbol of its wealth. A king affirmed his power or his divinity by the multiplicity of his portraits diffused in the hands of the merchant, the sailor or the soldier. Both sides of this complex are abundantly illustrated in our cabinets of medals: the symbol as the materialization of an intellectual concept, the portrait—which appears in its full development during the Hellenistic period, and above all during the Roman Empire—as the glorification of a man and the affirmation of his power.

That being so, we are bound to agree that the portrait and the symbol, considered as a physical description, compose the substance of the modern medal, which is an original creation of Pisanello. But Pisanello, one of the most prominent artists of the Renaissance, was very well aware of a tradition which he received as an incentive, and modified according to his own genius.

The fact that ancient coins have been valued and conserved for their artistic qualities is attested not only by the signatures of such proud engravers as Kimon and Evainetos at Syracuse, at the end of the fifth century B.C., and by the enormous production of the so-called medallions during the Roman Empire, but by the formation of collections whether in the treasuries of the Greek temples, or in the palaces of the Emperors. We know that Augustus distributed ancient coins to his friends as new year's gifts; and we may be sure that a similar practice was observed during the Middle Ages, in the monasteries. Whole series of these small but eloquent monuments were disposed in the libraries, to be referred to as a medallic history, and that conception adopted by Petrarch, for instance, is still alive in the British Museum or in the Bibliothèque Nationale in Paris.

The result of these proceedings was that imitations of ancient coins were produced from time to time during the Middle Ages, above all the famous '*augustales*' of the Emperor Frederic II, in the thirteenth century, whose types reproduce those of the late Roman emperors and copy the official titulature of Augustus. The works of the Sesto family, engravers at the Mint of Venice in the fourteenth century present other examples of such influence, and the medals

of Francesco of Carrara, which were formerly considered by many scholars as false Roman coins, opened the way to the medal of the Renaissance, with a portrait of the lord of Carrara very much like the effigy of Vitellius.

During the following period, many princes indulged in the noble hobby of collecting coins. Among the most prominent Mæcenases and aristocratic amateurs, we may cite Alessandro Sforza, Giovanni Bentivoglio of Bologna, Varanni at Camerino, Baglioni of Perugia, and above all Sigismondo Malatesta, Lord of Rimini; not forgetting Alfonso of Aragon at Naples, Filippo Maria Visconti, Duke of Milan, Francesco Gonzaga and Isabella d'Este at Mantova. So the ground was prepared for the invention of Pisanello.

On the other hand, it is necessary to insist on the importance given at that time to the characteristics of an individual, considered as a type of humanity. It is noteworthy that at the end of the fourteenth century a physician at the court of Este, at Ferrara, Michael Savonarola, the uncle of the famous friar who perished in dramatic circumstances at Florence in 1498, published a treatise on physiognomy, under the title of *Speculum phisionomie*. This worthy was a friend of the philosopher Guarino da Verona, the Greek scholar Theodor of Gaza, Lionello d'Este, lord of Ferrara, and Pisanello. In his work, he intended to classify the different human types under the seven planets and the 12 signs of the Zodiac, and he was highly interested in the form and proportions of the human body. We are bound to admit that such precepts were adopted by our medallists. Meanwhile, under the influence of Leo Battista Alberti, the celebrated architect and theorician, and of the champions of neo-platonism, Gemisthe Plethon, Bessarion, Cristoforo Landino, and Marsile Ficin, we perceive the rise of a philosophy of art. Beauty is the reflection of the soul, proclaims Alberti, and he uses such terms as *numerus*, *finitio*, *collocatio*, to give a definition of the perfect work. Art is a suggestion and an incantation at the same time, its object is to give food for thought much more than slavishly to reproduce reality. At the same time, art is an instrument of knowledge. The task of an artist is to reconstruct the world. The contemporary painters, Masolino da Panicale, Uccello, Andrea dal Castagno, Pinturicchio, and Piero della Francesca were educated by the scholars and philosophers in a science which they applied attentively to the elaboration of their works.

As a portraitist, Pisanello was engaged in the same ways. His purpose was to express the *virtú* of his models, that is the whole of a character, the talent of a personage, his temper, his gifts, the essence of his psychology. The *virtú* resides not in the conquest of a moral absolute, but in the realization, by each *uomo singolare*, of his own likeness, without yielding to fortune or circumstances. Such is the man of the Renaissance, conceived by Marsile Ficin or Pico della Mirandola, and later by Machiavelli. The aim of the portrait painter is summed up in these lines of Ghirlandajo: *Ars utinam mores animamque effingere posses, pulchrior in terris nulla tabella foret.*

We discern in the development of these conceptions the strength of the art of Pisanello. A careful reproduction of the features of Lionello d'Este, Cecilia Gonzaga, and Sigismondo Pandolfo Malatesta, the modelling of a countenance,

its arrangement in the circle of the medal, the balance of the lines and the volumes, all that is insufficient if we are not able to add to the effigy the plastic commentary which, expressed on the reverse, will achieve the spiritual suggestion of a prince, a condottiere, an unfortunate virgin. A full repertory of forms presents itself to the artist; landscapes, fabrics, and a whole menagerie which emanated from the antique bestiaries already commented by Leonardo da Vinci; an elephant will represent prudence, an eagle surrounded by vultures, magnanimity. That is the exquisite task of the true medallist; the search of an *impresa*, a symbolic composition alluding to the secret qualities of the personage represented is his ineluctable duty. *Impresa* is consequently the counterpart of the portrait. But the medal is still inadequate if it does not bear a motto, that is, a device which will bring the design to perfection, the words and the letters being used to fulfil the suggestion. Suffice it to add that indeed many collections of devices were published at that time, for instance that of Poggio.

And now we come to Antonio Pisano. He was born at Pisa in 1397, and was thus a contemporary of Brunelleschi, Ghiberti, Donatello, Fra Angelico. He settled at Verona where, during his youth, he was able to contemplate the frescoes of Altichiero da Zevio, Guariento and Avanzo. He began his career at Venice, where he was called with Gentile da Fabriano to repair the frescoes of Guariento and Antonio Veneziano at the Palace of the Doges. It may seem strange that the first of the medallists was a professional painter—his works at Santa Anastasia of Verona are still considered as masterpieces of the Renaissance. Moreover he was keen, on his medals, to identify himself as a painter: *opus Pisani pictoris*', he says. We find in his works, medals as well as painted portraits such as that of Ginevra d'Este, the same precision of outline, the same dryness of profile, as in the works of Pollaiuolo or Piero della Francesca. Still, we must remember that in the writings of Leo Battista Alberti the primacy of painting over sculpture is always alleged; he speaks of Phidias as a painter. In the famous bronze gates of the Baptistery at Florence, Ghiberti proves his gifts as a painter in the perspective and the relief of his compositions, and he says: *l'animo mio alla pittura.*

Nevertheless, and in spite of its initial conception, technically the art of Pisanello is that of casting. He was placed by his birth and circumstances in a circle of artists who endeavoured to be universal: painters, sculptors, architects and mathematicians at the same time. Above all, he lived in a time in which a great part of this energy was dedicated to metal. Donatello or Verrocchio, as well as Benvenuto Cellini later, won the admiration of the people by the elaborate execution of their huge statues, and on a smaller scale, Ghiberti and Filarete boasted of their mastership in casting exquisite panels in bronze. The great invention of Pisanello consisted of modelling in wax the likeness of a person, and a composition for the reverse; in forming from these moulds in sand or other matter, and in casting the bronze in the hollow thus shaped. The first medal, that of the Greek Emperor John Paleologue, was created in this way.

By a stroke of luck, it occurred that the event thus commemorated was one of

the most important of that time. In 1438 to 1439 the Emperor of Byzantium, threatened by the Turks who were to conquer Constantinople only a generation afterwards, tried to get some resources from the Occident for his defence. The best means seemed to be the reconciliation of the secular opponents, the Roman and the Greek Churches. A Council was summoned at Ferrara, but the plague compelled the imperial visitor, with his followers, bishops, metropolites, scholars, and theologians, to seek a refuge in Florence. It was, indeed, a strange procession which passed through the streets, and many artists were struck by the brilliancy of the dress of the dignitaries, above all by the figure of the unfortunate Emperor; by his pale face, his countenance, and his extravagant headdress *alla grecanica*. Among the throng were Piero della Francesca and Pisanello, and we fortunately have in the Louvre a precious collection of drawings which testify to the acuteness of the latter's curiosity. One of them represents Paleologue, with the adjunction of a few notes concerning the colouring of his face and robes. This drawing served as a preparation to the well-known medal which immediately met with an extraordinary success, and was reproduced everywhere. On the reverse we see the Emperor on his charger, joining his hands before a crucifix in a desolate landscape, praying for the expected 'union'. To the left of the Emperor, a page on horseback holds testimony to the cleverness of the painter in the art of representing animals, and in foreshortening. It is noteworthy that the title is written in Greek, and that the signature is twice repeated, in Latin and in Greek. With the Paleologue, the refugees from Constantinople were about to transform Florence into a Greek and platonic city.

We are thus led to consider what kind of people sat for Pisanello and his successors. They were representative men and women, not only princes like Lionello d'Este, Duke of Ferrara; Sigismondo Malatesta, tyrant of Rimini, and his mistress the fair Isotta da Rimini; Lodovico Maria Visconti, Duke of Milan, and King Alfonso of Aragon, but scholars like Guarino da Verona; friars and cardinals; *condottieri* like Piccinino or the Colleone; lawyers; men of war like Carlo Grati, and women like Cecilia Gonzaga or Nonnina Strozzi. In fact, we cannot get an adequate idea of the Renaissance without holding in our hands the medals of Pisanello, Matteo de Pasti, Sperandio, Niccolo Fiorentino, Laurana, Pietro da Milano, and Cristoforo di Geremia, *tutti quanti*, each of whom with more or less ability and penetration in his particular style, was able to give a kind of permanence to the ephemeral appearance of a human being, body and soul.

Clearly, many of them failed to attain the high degree of accomplishment that we require in a perfect medal. Success in the art of imagining a theme for a reverse is less frequent than the skill of mere portrait making, and we are fully aware that since the beginning of this process only the happy few deserve absolute praise. Among the medals grouped under the name of Niccolo Fiorentino, many have only very commonplace reverses: the figure of Hope or of a cupid, and lack of proper signification. Here appears the poor imaginative faculty of their makers, even when the effigy is not devoid of precision and subtle modelling.

Such an impulse had been given to the medallic art, that it lasted with the

same processes till the first part of the sixteenth century, but then the style changed with a new school of medallists, Leone Leoni, Jacopo da Trezzo, and Benvenuto Cellini, who produced smaller pieces, frequently chased after casting, such as delicate portraits of the Emperor Charles V, Philip II, King of Spain, and Hippolyte of Gonzaga, with the adjunction of pictural landscapes or somewhat pedantic and far fetched allegories. At the same time, Germain Pilon in France, and after him Jean Varin, and Guillaume Dupré executed large medallions, some of which are masterpieces, such as those of Catherine de Medici, Henri III, Charles IX, and above all, of the Chancellor de Birague, or King Henry IV.

Then a new technique appeared which entirely transformed the medal. It may be said that about 1550 a new art originated by virtue of new methods of coinage, and the introduction of a mechanism invented in Germany. Casting began to go out of use, and was progressively supplanted by striking. This is of much consequence. Following the example of the Roman Emperors, who could find in their gold coins, the *aurei*, the so-called medallions, the *sestertii* and the *denarii*, the full history of their reign, and because he had frequently wandered in the famous Cabinet du Roi, at Versailles, through his collections of antique coins, Louis XIV, incited by Colbert, conceived the great idea of the *Histoire Métallique*. The realization was due to the Petite Académie, founded in 1664, among the first members of which were Racine and Boileau, and which became the Académie des Inscriptions et Belles Lettres. Every event of the reign of the Roi Soleil was to be recorded in its series of gold, silver and bronze. The task of the academicians was to choose the subject destined to be joined to the changing effigy of the king: the victory of Leuctres, the reception of the Nuncio or the Spanish Ambassadors in the Hall of Mirrors at Versailles; the foundation of the Invalides, and even the lighting and cleaning of the streets of Paris. An inscription in Latin was carefully drawn up, and adopted after many discussions. Then a draughtsman, Antoine Coypel was invited to give form to the idea by representing a landscape, a monument, a battle, or an allegory. At last, the approved design was delivered to the most skilful engravers, and the dies worked up in the 'Monnaie des Médailles', that is, a separate department of the Royal French Mint. So great was the importance assigned to the *Histoire Métallique*, that all the medals, with an appropriate commentary, were published in a sumptuous folio by the Pères Ménétrier, in 1702, and the activity of the 'Monnaie des Médailles' lasted till the end of the eighteenth century, under Louis XV and Louis XVI.

Likewise Napoleon entrusted to a special class of the Institute the elaboration of the medallic history of his reign, and if the majority of the medals thus projected could not be executed, we possess the drawings of Chaudet and Lemot, accompanied by their specifications written in a somewhat bombastic style.

We have till now treated exclusively of the Italian and French medal, and it is true that to the supremacy of the Italian art of the Renaissance succeeded a taste or a fashion which was spread from France and dominated all Europe. There is no essential difference between a medal of Louis XVI by Duvivier, the admir-

able portrait of Montesquieu by Dassier, and those of Giles Strangways, prisoner in the Tower in 1648, which was the work of John Roettiers; the Queen Mary, by John Boskam; Frederic William, elector of Brandenburg, by Höhn; the King Charles III of Spain by Gil; Gustav Croningen by Hedlinger; the Emperor Charles VII and his Empress Maria Amelia by Schega. This is so not only because the manners and attitudes are the same, but because the technique and the style impose a similar aspect on all of them.

Nevertheless, it is indispensable to observe well the peculiar forms the medal was endowed with in certain countries—first, Germany, where it followed original ways. There, at Nuremberg and Augsburg, the medal was above all the art of goldsmiths and wood cutters, not so much aristocratic as popular, and dedicated to the good townsmen. The medallists carved a model in box-wood, which might be preserved for itself, as an independent work before the casting in metal. This is the handicraft of the '*Formschneider*', so clever during the sixteenth century, which made the fame of Joachim Deschler; Hans Schwartz; Hans Kels; Bolsterer; Peter Flötner; Mathes Gebel; Hagenauer, and many others. You will not meet in this company the gorgeousness, the tendency to physical domination that is so prevalent among the Italians, but an acuteness in the carving of the profile and the volumes of the face, which lends to the best of this production a kind of intimate charm mingled with an ingenuous roughness. A medal like that of Hieronymus Paumgartner represented in full face, or that of Elisabeth Fichard by Bolsterer may be taken as very significative examples of a psychological moment.

But taking into account this technique and its peculiarities, we are bound to regard the German medal of the sixteenth century as a domain practically without communication with the outside. The composition of a reverse does not play any part in this affair, all the interest being concentrated on the portrait, even on the medals attributed to Albert Dürer, who did not display his imagination in this way as we might have expected.

Flanders proves its originality in the medal of the painter Quentin Metsys, by himself, or the very conspicuous portrait of Erasmus by the same master, well deserving to be compared with the famous painting of Holbein which brings to life again one of the most prominent figures of European humanism. The portrait of Perrenot de Granvelle by the poet Jean Second, is equally well imbued with the Flemish spirit.

The other productions of the medallic art in the low countries partake of the art of the Milanese medallists, for instance the medal of Margarete of Austria, by Jonghelinck. The reverse is conceived in the same way as those of Jacopo da Trezzo or Leone Leoni.

In England we could cite the precious medal of Queen Elizabeth by Nicolas Hilliard, chased as a jewel, and the exquisite works of Abraham and Thomas Simon, very attractive little pieces which show us Cromwell and the sitting of Parliament after the battle of Dunbar, in 1650, or delicate portraits of personages of the middle of the seventeenth century.

It does not seem necessary to enumerate all the artists who indulged in the

medallic art during the following period. The medal never ceased to be cultivated in various countries till the present time. It is well worth observing that the tradition of the *Histoire Métallique* is still in full vigour nowadays in France at least, and that independently of what we may call the private medal, dedicated to more or less prominent or modest individuals according to the taste of affectionate families or deferent societies, the Mint of Paris considers as its task the commemoration of the principal events of our history, and celebration of popular anniversaries. The medal is still following its independent career.

Indeed the great currents which have carried the other arts have also influenced the medal, but without altering its individuality. In order to stimulate its actual and æsthetic revival, many devices have been tried. In the preceding generation, Chaplain and Roty, in France, enjoyed a true popularity which was shared by many others, and their activity was considerable. But the point in question was then to produce realistic portraits, and what the public requested was the art of fixing a likeness. On the reverse a scene taken from life, when it was not an allegory not altogether out of use, pretended to show a personage, magistrate, physician, Member of Parliament or President of the Republic, in the exercise of his duties. Nowadays it seems that we are tired of that sort of pragmatism, as well as of all those pseudo-antique ladies, holding palms or wreaths, seated on the edge of a building or a locomotive, and we are fortunately more attracted by a new symbolism. On the other hand we have seen some portraits constructed according to a kind of geometry, inspired by cubism, so that surrealism and abstraction acceded in a domain which was considered till then as obsolete. It appeared that the anecdote, or an historical narration, carried the medal into a kind of blind alley, because the medallist is confined in a narrow field and if he wants to avoid falling in a tiresome minuteness, he is bound to concentrate his efforts on a few objects bearing subtle allusions. By this means we rejoin the symbolisms of the ancient masters. A symbol is a suggestion, it is neither a full description nor a discursive relation. The Greeks and Pisanello were perfectly conscious of this verity, and thus discovered the magic and the strength of the art here considered.

But speaking of the medal we must always keep in sight the technique which commands the whole scheme. Once more machinery interfered to modify the medal and even ventured to determine a complete transformation in its process. During the last century an invention, the so-called '*tour à réduire*' permitted the diameter of a model, executed on a more or less large scale by the artist, to be changed at leisure. That is, of course, a simplification; it is at the same time a danger. We know from experience that an amateur will frequently feel that there is a deception when, after examining an original model, and appreciating its qualities, he sees the corresponding medal issued by the press and conveniently reduced. In spite of an exactness which is very much praised, if the proportions remain strictly the same, the figure inscribed in our visual ground does not produce the same kind of fascination. It means that the mechanical reducing has to be performed with great scrupulousness. That is why, in recent times, many medallists showed a reaction against such practices. Some of them

returned to the technique of casting, which requires very experienced workmen, and does not allow easy reproduction of a great number of examples. The advantage is that a greater suppleness is thus acquired, and at the same time that every specimen is endowed with more personality. Others also were so courageous as to revert to the '*taille directe*', that is, the immediate engraving on a block of steel. That is perhaps the most difficult of the handicrafts, that of the ancient die cutters, and it requires a prolonged apprenticeship, but it rewards highly those who are bold enough to tap its peculiar resources.

The medal, destined by its nature to a large diffusion, to a practically unlimited reproduction, is nevertheless confined to skilled amateurs. Among all other productions of art, its purpose is to be taken in the hand, presented to the diverse incidences of the light, which touches the reliefs differently according to the pleasure of the spectator, offering at the same time a theme for mental reflection. We must remember that it is the most intellectual of the arts. As it reached a kind of perfection at the outset, it seems that multiplying under the most unrestrained forms, and accepting every kind of suggestion, it would nevertheless be unable to progress without remaining faithful to the principles which gave it its nobility in the course of a glorious past.

DISCUSSION

THE CHAIRMAN: After that wonderful survey I hope Monsieur Babelon will be willing to answer the questions which members of his audience will, I know, want to take this opportunity of raising.

MR. H. BAILLIE RITCHIE: It seems that at one point in the production of medals the process moved from casting to dying or stamping. Am I right in making that conjecture?

THE LECTURER: Yes.

MR. RITCHIE: Approximately what was the year?

THE LECTURER: I think the process of striking coins began from an invention in Germany in the middle of the sixteenth century.

THE CHAIRMAN: To what extent do you believe Pisanello was influenced by the Roman medallion?

THE LECTURER: I think that if he may be said to have looked at Roman medallions, we cannot observe a direct influence of ancient coins on Pisanello's medals. We should be justified in speaking generally of a kind of emulation.

MR. KENNETH CLARK: Are most of the French and Italian medals commissioned, or are the majority carried out by the artist for his own pleasure?

THE LECTURER: There are special commissions in the French Mint for choosing the subjects to be treated by the medallists and then orders are given to different medallists.

MR. J. R. PINCHES: I have noticed that one has no chance to exhibit medals unless they are at least three inches in diameter. I would like to express my thanks on behalf of my fellow craftsmen for this magnificent exhibition and to the Royal Society of Arts and to both lecturers, but if fashions are changed and we are now

going through a period of cast medals instead of struck medals then they must surely be on a larger scale. How are most medals in this case cast? Are they sand castings or metal castings? As a designer it does not seem to me that any of the work I have done, or that I or my colleagues have reproduced, stands any chance because it is on a smaller scale and the medals in commerce are little bigger than two inches or one and a half inches or less.

SIR LIONEL THOMPSON, C.B.E. (Deputy Master of the Royal Mint): I have been thinking of what Mr. Pinches said and it occurs to me that the size of a medal depends on the use to be made of it. If it is to be worn, obviously it cannot be too big. It must be limited in size to at most two inches. In our British medals the standard size is just under one and a half inches in diameter. In this country I think the major use of medals has been for wear, but you do find, as Mr. Pinches will agree, that the prize medals, such as are presented by this Society and others, are a slightly larger type. In the Continental countries, so far as I have been able to judge, the medal may be an ornament for the wall of a dwelling rather than for the person; and therefore you would in that tradition presumably get larger medals and would be able to use the casting technique with a higher relief.

MR. PINCHES: Are those medals doubled sided? Are they cast as medals or are they two separate sides of a medal, cast by either of the processes which I mentioned, and welded or stuck together some way or another?

THE CHAIRMAN: Monsieur Babelon has presented for us perfectly the historical setting of the present exhibition. At the beginning of the exhibition Dr. Sutherland spoke of the modern situation and possibilities for the medallist, and Monsieur Babelon has completed the picture by displaying the historical background.

I cannot help feeling that he has stressed indirectly throughout one very important thing, that is, the part played by *balance* in the production of a fine medal in two ways. One very important sort of balance, as Monsieur Babelon has shown us, is the balance or harmony between the obverse and reverse of a single medal. The reverse is the counterpart, the interpretation of the obverse; and I cannot help feeling it a significant point, although I am sure the Deputy Master of the Mint does not want to hear my views as to what coinage should be like, that in the medals of the finest period the obverse and reverse were the work of a single master, and they formed a unit; surely, in spite of the difficulties involved, a coin or medal should ideally be of that character.

Then the other sort of balance which Monsieur Babelon has illustrated so well is that familiar problem of tradition *versus* originality. It is clear that the finest medallists, in earlier as in modern times, have achieved—in varying proportions—a very satisfactory balance between the tradition they inherited and the originality of their own minds. After looking at the exhibition, I feel that the same is apparent, very visibly, in the best medallists of to-day. Certainly some of them display the originality which is a necessary ingredient. I am very often told by my university colleagues who know more about the Renaissance than I do that the Renaissance did not exist, or there were several different Renaissances and that of the fifteenth century was not necessarily a very important one. I am very puzzled about this current theory of history and I feel that when one looks at medals one is even more puzzled, because it would seem to me that Pisanello was an exceedingly original artist; and if one studies the medals it seems impossible to deny, at any rate in that field, that the Italian Renaissance existed and was vitally important. One feels inclined to agree with E. M. Forster when he remarked recently that some of those who dislike the Renaissance are really saying this because they dislike humanism. I have a vested interest here because the name of my department in the University of Edinburgh is the Department of Humanity, and I do not like people running down the humanists.

Monsieur Babelon said we cannot get an idea of the Renaissance without handling medals; equally, I believe, a student of medals cannot doubt the reality of the Renaissance, and a student of medals is particularly well equipped to understand humanism because, as we have seen from M. Babelon's remarkable selection of microfilms, the medal is not only official and commemorative (as Roman medallions had been), but it is personal, it is human, and as the lecturer has said, it is intellectual. M. Babelon has summed up its character and interpreted it in the most remarkable way—and, may I add, in excellent English. A lecturer who can speak in a foreign tongue in that extraordinarily able fashion is indeed to be envied!

I am sure you will all wish to join me in thanking him very warmly indeed for coming here to-day, and for giving us this remarkable paper.

A vote of thanks to the Lecturer was carried with acclamation.

SIR GORDON RUSSELL, C.B.E., M.C., R.D.I. (A Member of Council of the Society): May I on your behalf and on behalf of the Society thank Professor Grant for taking the Chair so adequately to-day at this fascinating lecture, which is such a fitting conclusion to the Society's exhibition of medals. May I also thank the Royal Numismatic Society for the help they have given to the Royal Society of Arts in collecting this exhibition together, and I would, if I may, say how pleased we are to see the Deputy Master of the Mint, Sir Lionel Thompson, and thank him too for the personal interest he has taken in the exhibition and for his willingness to show some of us round the Royal Mint.

A vote of thanks to the Chairman was carried with acclamation, and the meeting then ended.

GENERAL NOTES

CHARLES POWELL AND THE BRECKNOCKSHIRE AGRICULTURAL SOCIETY

Recent research into a group of letters received by the Society of Arts in its earliest days from Charles Powell has shown the influence which the Society of Arts, of which Charles Powell was a member, exerted over the formation of the Brecknockshire Agricultural Society, which has celebrated its Bicentenary this summer and whose Annual Show was attended by Her Majesty The Queen during her visit to South Wales in August.

This research was prompted by an enquiry made by Mr. Henry Edmunds, the Brecknockshire County Agricultural Officer, at the suggestion of Dr. Frank R. Lewis, a former Assistant Secretary of the Royal Society of Arts. The letters not only show the keen participation of Charles Powell in the activities of the Society of Arts, but also, in spite of their modest language, substantiate the claim which is now made for him to be the real founder of the county society. The work of both bodies in their early years consisted mainly in the offer and award of premiums, and it is with these offers by both societies that the Charles Powell correspondence mainly deals. The close link which existed between the two societies in their first years is also demonstrated by the fact that a list of the premiums offered by the Brecknockshire Society is appended in the *Gentleman's Magazine* for 1755, pp. 505 ff., to an article describing the work and progress of the Society of Arts.

An article by Mr. Edmunds giving a brief history of the Brecknockshire Agricultural Society, which was originally prepared for the *Brecon and Radnor Express and County Times*, is reproduced here with the kind permission of the Editor of that newspaper:

The county historian, Theophilus Jones, wrote in 1805—"The progress of the Science of Agriculture, though not in so improved a state as in the vicinity of the Metropolis (London) and the large cities and towns in England, has yet advanced much further in Breconshire than in the neighbouring counties of the Principality.

'This superiority we certainly owe in some measure to the establishment of the Breconshire Agricultural Society, first instituted in the month of March, 1755'.

The most prominent persons in its establishment appear to have been Sir Edward Williams, Gwernfed, Charles Powell, Castle Madoc, and Howell Harris of Trefecca.

The original terms of reference might be described as 'the encouragement of Agriculture and Manufactures and promoting the general good of the county'. In 1817 the Society was reorganized and its aims were readjusted to suit the requirements of the time. From then onwards, the objects of the Society were the promotion of experimental farming, the purchase of agricultural books and implements, and the granting of premiums. The avowed aims of the Society were indeed extensive, and it speaks well for the enthusiasm and energy of members over two centuries that they were able to fulfil in a remarkable degree most of what they had set out to achieve.

What, then, caused the founder members to meet and to devote so much of their time and money towards a progressive agricultural mission? The root cause was the sharp increase in population in Britain in the 18th century and the demand for more food. Fortunately, one of the means whereby more food could be produced was with us, for in the early part of that century turnips were known only as a vegetable and not as a farm crop. Present-day farmers might pause here and think awhile of the enormous value of roots and green crops in their modern economy. They help to clean the land, or they should do, they fatten lambs, they feed ewes in the spring before and after lambing, they provide fodder for all sorts of cattle through the winter. Roads were bad and so fodder of any kind was difficult to buy; consequently, 200 years ago, hay, grain and straw were the only winter stock foods.

How right and how wise were the members of the Society to encourage the growing of turnips and swedes! For about 120 years, they granted cash premiums for drilled root crops. In 1756 a William Pugh of Talgarth received an award for the best field of 20 acres of turnips. About a century later, Thomas Price, Fenny Fash (1841–48–52) and John Price, Tynewidd, Lower Chapel (1858–1863) were regular winners for the same crops. The descendants of both these men are present-day farmers in the county and are worthy upholders of the value of roots for farm stock. Obviously, much better methods have developed since 1755, but again the early members of the Society are to be praised for their efforts in encouraging farm workers to hoe and single well. They also imported into the county and newly developed root drill, which had been developed in England by Jethro Tull.

Apart from turnips, other crops were liberally supported. In 1769 Thomas Parry of Cwmdu received one guinea for his foresight for 'sowing rye in stubbleland in the autumn to feed off with sheep in the spring to prevent his meadow land from being grazed'. It would be a good thing, even to-day, if more farmers followed the practice of Thomas Parry. Red Clover was another immensely valuable crop, to which the Society gave their financial blessing. In 1773 a premium was given to farmers for the greatest acreage of first year clover cut for hay. In 1810 three guineas were recommended for 'The greatest quantity and the best quality, not less than 3 cwt., of clean clover seed, raised within the Hundreds of Builth, Merthyr and Devynock'.

Land drainage and land reclamation were not forgotten. Around 1800, the period of the Napleonic Wars, grain crops rose enormously in value. In 1797 wheat at Crickhowell was worth 8/6 to 10/6 a bushel, but by 1801 it reached 30/–. Oats and barley were cheaper, but they too doubled in price. The incentive for more intensive cultivation was there and this the Society fostered. They had, over many years, tried out many new ploughs which were light in draught and capable of being drawn by horses. The old plough was a heavy affair, needing 4-6 oxen; the ideal aimed at was a plough on which 2 horses could do a good job, more quickly and cheaply.

Interest in livestock did not concern the Society's members until about 1780, and their early premiums were for stallions to improve the working horses of the county. This type of premium lasted until very recent times, until the cart horse gave

way to the tractor. With sheep and cattle the Society were concerned only after about 1790, but thereafter their money was generously distributed, right up until the present day. This late start with cattle and sheep premiums, compared with crops, was in the right order of things. The fodder for keeping stock through the winter had to be assured before stock numbers could be increased. To have improved the stock before being certain of food to feed them would have been a case of putting the cart before the horse.

Fortunately, it appears that by about 1790 to 1800 crops in quantity were becoming available, for it was at this time that Hereford cattle first entered the county. These were superior to the native Welsh Blacks and now extinct Glamorgan Reds in that they matured earlier, provided the food was at hand. In 1818 two premiums of 5 guineas each were to be awarded for the best yearling and aged bull and the bulls were to be inspected in the yard belonging to the Golden Lion Inn (now Brookes Showrooms, Lion St.) In 1895 there were 18 classes for Herefords, with a prize list amounting to £68.15.0, which in to-day's value of money would be £300.

With sheep the Society was equally encouraging and generous, realizing as it undoubtedly did their importance in the farming economy. As early as 1767 premiums were awarded for folding of sheep on turnips. In 1810 3 guineas was granted for the best fleece of wool. In this same year an unusual breed, namely the Spanish Merino, came into the premium list. This breed had become fashionable in landed circles in England around the turn of the century, but its real value fell short of what had been claimed for it. In Breconshire its life, even if it began, must have been short. More popular were the improved Leicester sheep, the product of that great breeder Charles Bakewell. Thomas Longfellow, of the Golden Lion Inn, who in addition to being a publican and farmer, was also the Secretary to the Society from 1761–1794, bought from Bakewell 20 Leicester ewes, and when crossed with a local breed ram, produced good lambs which realized £2.12.6d. each in 1776. At a later date, 1805, Penry Williams (1783–1847), Penpont, had Leicester sheep, but he complained that they needed far more food than local breeds.

In 1864 and 1876, there were classes for long wool and short wool sheep. All our present breeds are short wool types and consequently the exact nature of the long wool breeds, then prevalent, is unknown. They may have been Leicesters or even the now almost extinct Cotswold breed. The short wool breeds were almost certainly the Ryeland and Shropshire, both of which have been almost entirely replaced by the modern Clun and Suffolk.

STEUBEN GLASS EXHIBITION

An exhibition of Steuben glass is to be held from 14th October to 9th November, 1955, at Park Lane House, 45 Park Lane, W.1.

Steuben glass is named after the county in New York State in which the Corning Glass Works is situated. This high-quality crystal glass has been manufactured since 1933 as a special department of a concern which has been operating for a hundred years. No mechanical processes are employed by the craftsmen, and the designs of many distinguished artists are employed for the engraved crystal.

There will be an admission fee of 2s. for the benefit of the Educational Trust of the English-Speaking Union of the Commonwealth.

POLYTECHNIC MANAGEMENT ASSOCIATION

The Polytechnic Management Association, which was founded three years ago on the lines of similar associations in other centres, is an association of managers and administrators in the London area who hold or who are in the course of completing the Diploma of Management Studies. The Association aims at providing

a forum for the exchange of views and experiences, and is holding in November and December a series of lecture–discussions on the subject of 'Leadership in the Twentieth Century'. The guest speaker will be Lt.-Col. L. Urwick, O.B.E., M.C., a Silver Medalist of the Society.

Details can be obtained from: The Secretary, Polytechnic Management Association, St. Katherine's House, 194 Albany Street, N.W.1.

BRITISH CRYSTAL GLASSWARE SYMBOL

A further symbol representative of a class of British craftsmanship is about to be introduced. The Glass Manufacturers' Federation announce that from 1st October those members of the Federation manufacturing hand-made crystal glassware will adopt a symbol to denote their similarity of interest. The symbol, which is also intended to focus attention on the product, shows the British lion rampant, holding a blowing iron, the traditional tool of the craft, and encircled by the words, 'G. M. F. British Hand-Made Crystal'.

OBITUARY

MR. STEPHEN GOODEN

We record with regret the death, at his home in Buckinghamshire on 22nd September, of Stephen Gooden, C.B.E., R.A.

Mr. Gooden was in the forefront of those artists of his generation who were concerned with the revival of line engraving. He was born in 1892, and educated at Rugby and at the Slade School. Beginning as an etcher, he later turned to engraving, and in 1935 first exhibited at the Royal Academy. Among his many works, the majority of which were book illustrations and decorations, were the book plates for the Royal Library at Windsor, and his design for the *Book of Revelation*. Examples of his work are exhibited in various museums. In 1942 Gooden was created C.B.E., and in 1946 he became a full member of the Royal Academy having been elected an Associate in 1937.

Mr. Gooden was elected a Life Fellow of the Society in 1953.

NOTES ON BOOKS

GREAT AIRMEN. *By Wing Commander Norman Macmillan. G. Bell & Sons.* 1955. 12*s* 6*d*

In aviation there is a closer association between the personalities of the pioneers and their achievements than in other branches of engineering, and in consequence studies of these men are always of interest. In this comparatively short book, of 270 pages, Wing Commander Macmillan brings together the men and their work in a series of admirably direct and informative sketches. After looking forward in the first chapter, 'Heading for space flight', in which he deals with pilots of rocket-powered aircraft such as Yeager and Bridgeman, the author looks back over the half century extending from the first flights of the Wright brothers to the jet aircraft test flying of Lithgow and Neville Duke.

All those who discuss early aeronautical work in this country find themselves facing a difficult problem when they treat the first flights. Cody was an American citizen and there is an unhappy and unresolved controversy between Sir Alliott Verdon Roe and Lord Brabazon. Wing Commander Macmillan does not include either Cody or Lord Brabazon in his list, but he relates the actions of the Royal Aero Club when it sought to establish historically the date of the first flight by a British subject in Britain and gave that honour to Lord Brabazon. Many believe that this was a wrong decision and that Sir Alliott Verdon Roe should have been named for his flights of the 8th June, 1908. In any event Sir Alliott deserves special notice because he was a pilot-constructor.

Wing Commander Macmillan covers a wide field in his selection of great airmen; and his choice is rightly dictated by his personal views. For as a military pilot of the First World War and, subsequently, a manufacturer's test pilot, he has earned the right to pick and choose. Nevertheless it is impossible to resist the temptation to express regret that the two men regarded by the present reviewer as the greatest pilots of all are not included: they are Pégoud and Stainforth. Célestin Pégoud was the first to loop, to bunt, to fly inverted, to make a parachute descent from an aeroplane, to do a hundred other things which advanced the art of pilotage and airmanship. George Stainforth was one of the most perfect pilots the world has seen. His flying technique was almost faultless. He was equally at home when attacking the world absolute-speed record and when doing extremely advanced aerobatics in a low-powered light aeroplane. But it would be ungenerous and unfair to over-emphasise the omissions. All who have followed aviation since the early days have their special favourites. And all will acknowledge that the author of *Great Airmen* has made a sound selection and a selection which helps the reader to see aeronautical progress in perspective and to understand the force that was exercized by its leading personalities.

The book is well produced and has pleasing line drawings of aircraft by John Young.

OLIVER STEWART

FROM THE JOURNAL OF 1855

VOLUME III. *28th September*, 1855

From a report on The Society's Visit to the Paris International Exhibition.

The following address was placed in the hands of M. Le Play, for presentation to His Imperial Highness on his return to Paris:—

"May it please your Imperial Highness,

"We, the Council and Members of the incorporated Society instituted at London in 1754, for the Encouragement of Arts, Manufactures, and Commerce, together with the representatives of the Literary, Scientific, and Mechanics' Institutions throughout Great Britain and Ireland associated with us, beg leave to congratulate your Imperial Highness on the great success of the Universal Exhibition of all Nations.

"In accordance with the recommendation of His Royal Highness the Prince Albert, our illustrious President, we have visited the splendid capital of France to mark the progress of Arts, Manufactures, and Commerce. We have noted with great satisfaction their rapid advancement since the opening of our own Exhibition in 1851, whose universality, its dominant idea, was due to the comprehensive views of our Royal President. On every side we witness manifold proofs of the energetic will and organizing power which have rendered the name of Napoleon so illustrious. The indefatigable zeal of your Imperial Highness has happily realized the grand conceptions of His Majesty the Emperor, and we are thus once more permitted to behold the great spectacle of the confederacy of nations, and the reunion of those men whose works and discoveries are the true glory of our age. It is only by gatherings such as these that we can hope to reunite in the firm bonds of lasting peace the great family of the nations of the globe. The moral good thus accomplished will be of more value than even the material results. The harmonious accord of the two great nations, France and England, which stand confessedly at the head of European civilization is the surest pledge of its conservation and advancement.

"Accept, Illustrious Prince, the homage of our profound respect,

"Given under our Common Seal this 8th day of September, 1855.

"JAMES BOOTH, Chairman of the Council.
"P. LE NEVE FOSTER, Secretary".